

# Long-term observations of $^{14}\text{CO}_2$ at Jungfrauoch

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## 1. Project description

Radiocarbon observations on carbon dioxide sampled at Jungfrauoch are being performed by the Heidelberg University since 1986. From 2018 onwards, these samples are taken for the University of Bern due to their involvement in the Integrated Carbon Observation System Research Infrastructure (ICOS RI). Jungfrauoch is an official ICOS class-1 station. The sampling protocol follows the specifications given by the atmospheric specification document for ICOS stations (ICOS RI, 2020). The staff of the International Foundation High Altitude Research Station is collecting the samples according to this protocol, i.e. chemical trapping the  $\text{CO}_2$  from the air flow when passing through a NaOH solution. We experienced no major problems in 2023. The samples from the second half of 2021 that were forgotten to be sent to Heidelberg have been measured meanwhile. The  $^{14}\text{CO}_2$  measurements are done in the ICOS Central Radiocarbon Laboratory (CRL) at the Institute of Environmental Physics of Heidelberg University and the data are available via the ICOS Carbon Portal ([www.icos-cp.eu](http://www.icos-cp.eu)). Data before 2018 have been published as a separate data set by Levin et al. [2021]. Recently an updated database report was published [Levin et al., 2023].

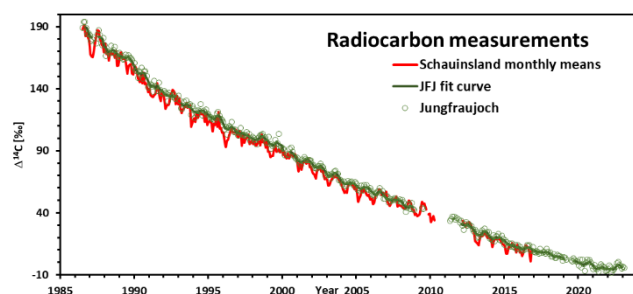


Figure 1. Atmospheric  $\Delta^{14}\text{CO}_2$  observations at Jungfrauoch (green circles) in comparison to values of the Schauinsland station (red curve). The green line corresponds to a 5-months running mean of the Jungfrauoch values. Data from JFJ between January 2009 and April 2011 as well as from May 2010 to February 2012 have been preventively skipped due to pending calibration issues.

Also this year the  $^{14}\text{C}$  record from Jungfrauoch has been used widely as reference in many publications ([Baldini et al., 2023; Finstad et al., 2023; Grootes et al., 2023; Povinec et al.; Povinec et al., 2024; Sironić et al., 2023; Zhao et al., 2023]).

$\Delta^{14}\text{C}-\text{CO}_2$  is decreasing due to the  $\text{CO}_2$  exchange with the other carbon-containing reservoirs such as the ocean and the land-biosphere, but since the 1990s almost exclusively due to the ongoing (global) input of  $^{14}\text{C}$ -free fossil fuel  $\text{CO}_2$  into the atmosphere i.e. the global Suess effect (Fig. 1). In late 2019, the  $\Delta^{14}\text{C}$  values reached zero permil.

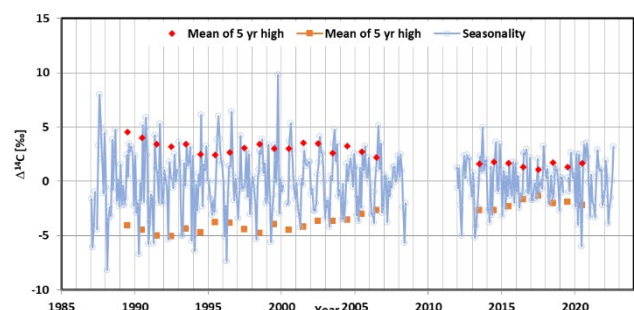


Figure 2. Seasonal amplitude of the Jungfrauoch record based on the monthly values from 1987 to 2022. The preventive gap between January 2009 and April 2011 lead to a gap in seasonality values of 3.5 years due to its calculation.

We further investigate whether or not an 11-year cycle is recorded in the radiocarbon record from Jungfrauoch. At least the updated records point again to an amplitude increase. Studies that investigate the causes for such a cycle seen in Earth observations have been published [Brehm, 2023; Chen et al., 2023]. The quasi-biannual frequency signals mentioned in the last annual report have been investigated based on tropopause pressure changes that are indicative stratosphere-troposphere exchanges (STE). It is interesting to note that from time to time stratospheric intrusions are reaching Jungfrauoch. This is illustrated in Figure 3 by a channel of stratospheric air reaching out to Jungfrauoch. Such channels facilitate STE and are then monitored at Jungfrauoch. We have

implemented a tool that such cross sections as given in Figure 3 are automatically produced once the data are available.

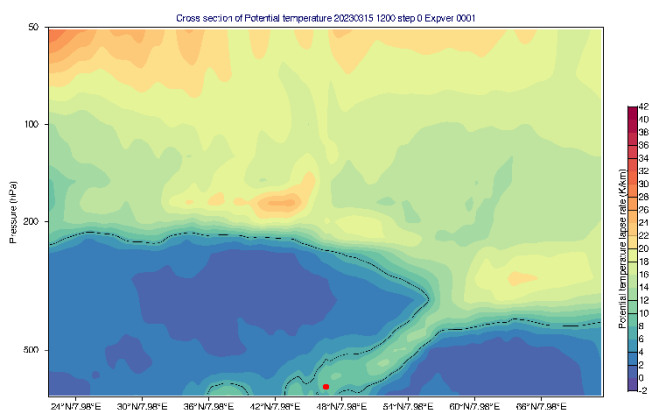


Figure 3. Cross section of potential temperature lapse rate (K/km) as a function of pressure and latitude. The red point in the lower middle part corresponds to the Jungfrauoch location. On March 15, 2023 there was a clear channel for stratospheric air reaching Jungfrauoch.

The minima and maxima of the mean seasonality at Schauinsland leads that at Jungfrauoch by 1 month. The amplitude is higher at Schauinsland compared to Jungfrauoch.

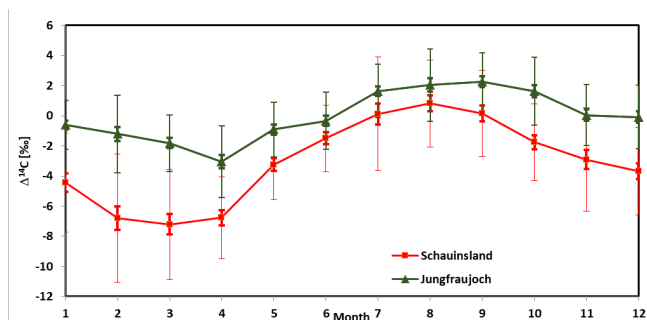


Figure 4. Mean seasonality of the Jungfrauoch and Schauinsland (shifted by the mean offset for the two stations during the overlapping period, i.e. 3.2 ‰). Corresponding uncertainty ( $1\sigma$ , thin line) and ( $1\sigma$  of the mean, thick line) based on the monthly values from 1987 to 2023 for Jungfrauoch and 1987 to 2016 for Schauinsland. January corresponds to month 1.

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## Internet data bases

- <https://meta.icos-cp.eu/objects/L2KPGw3qDafKMReHzH2qGs5o>  
<https://data.icos-cp.eu/portal/>

## Collaborating partners / networks

- International Foundation Hochalpine Forschungsstationen Jungfrauoch und Gonergrat (HFSJG)  
 ICOS-RI partner, ICOS-CH partners

## Scientific publications and public outreach 2023

### Data books and reports

- Levin, I., S. Preunkert, H. Graven, C. Lewis, J. Miller, J. Turnbull, X. Xu, and S. Hammer, Database of existing  $\Delta^{14}\text{CO}_2$  measurements, 2023.  
<https://www.corso-project.eu>

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